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PATENT SPECIFICATION

DRAWINGS ATTACHED

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COMPLETE SPECIFICATION

Improvements in or relating to Methods of and Devices for Treating Substances with Sound and Ultrasonic Waves

We, SIRIUS, a Body Corporate organized under the laws of Luxembourg, of 2bis, Boulevard Royal, Luxembourg, (Grand-Duché de Luxembourg), do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed to be particularly described in and by the following statement:—

This invention is concerned essentially with a method of treating any bodies, elements, substances, chemical compounds or micro-organisms occurring either in the form of a fluid or in the form of a powdered solid or of solid substances comminuted to particles of very small dimensions which are in suspension in a carrier fluid, with a view to facilitating their physical transformation and/or increasing their chemical reactivity.

It is known that most phenomena occurring in substances, whether of chemical or physical order, take place at the scale of the molecule or of the atom, this having led firstly physicians and subsequently technicians to sub-divide materials to the utmost in order, by approaching the molecule or the atom as much as possible, to facilitate these phenomena or even, sometimes, create phenomena which would not have taken place under the conditions in which the material generally occurs in the natural state.

Thus, in the case of chemical reactions, for example, a close contact between the substances involved constitutes one of the determinant factors of their combination. One is thus led to increase to the utmost the surface area of each body by dividing same to the maximum while producing simultaneously a strong agitation so that each elementary particle of a substance will contact elementary particles of the other body or bodies.

In a different field, that is, in the case of physical transformations, one may be led to divide a substance with a view to increase to the utmost the area per unit volume and thus use the phenomena caused by surface tensions which result therefrom, for instance.

It is also known to divide a substance not as set forth hereinabove with a view to carrying out a chemical reaction almost immediately or an instantaneous physical transformation, but for producing a delayed action; in this case, very fine particles are suspended in a fluid, that is, either an aerosol (if the fluid is a gas) or a hydrosol (if the fluid is a liquid).

The use of sound and ultrasonic wave energy for breaking the particles, stirring same and modifying the conditions of their activity has been known for a long time.

Although the basic principles open the widest outlook as to the theoretical possibilities afforded by the division of substances down to the molecular or atomic scale, the practical methods proposed up to now fall short of expectations and it is undeniable that most of the hitherto known ultrasonic wave treatment methods do not give the results one might theoretically expect from these basic principles. In many cases it is necessary to repeat the same treatment several times on the same body, for example by recycling same in ultrasonic wave apparatus, to endeavour to increase its state of division. In most cases the improvement resulting from this recycling method is rather limited and always very costly.

On the other hand, many physical transformations or chemical reactions which theoretically were expected to take place under predetermined conditions at the scale of molecules or atoms were not observed at all under these theoretical conditions when treating the substances with sound or ultrasonic

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waves through the hitherto known means. This proves that the principles which these methods are assumed to embody are applicable only to a limited extent.

5 While endeavouring to ascertain the causes of these failures, the Applicants found that on the one hand the hitherto known methods were actually unsuitable for dividing substances into sufficiently fine particles and
10 that on the other hand when these methods contemplate the stirring or agitation of the particles with a view to facilitating their mixing and therefore their reaction, they are actually unsuitable for carrying out the mixing steps under the best conditions with a
15 view to facilitating the desired reaction or transformation, either because the stirring is not strong enough, or because it is not effected at the proper time, although in most instances these two reasons are to be accounted for simultaneously.

20 In fact, the Applicants came to the conclusion that to facilitate the phenomena to which the substances are to be subjected it is necessary not only to divide these substances to the utmost, that is, more thoroughly than afforded by present practice, but also to mix them as the division takes place, in order to take advantage of the extra activity
25 exhibited by substances when they undergo any transformation, this extra activity being already known for example in the case of nascent hydrogen.

30 It is the object of this invention to provide a method for embodying the ideas expressed hereinabove, this method being remarkable notably in that for treating any substances, bodies, elements, chemical compounds or micro-organisms, in the form of
35 a fluid or a powdered solid or of highly comminuted solid particles in suspension in a carrier fluid, with a view to promoting and/or facilitating a physical transformation and/or chemical reaction involving said substances, it consists in causing at least one of said substances, for example with the
40 assistance of pressure means, to circulate through a plurality of circuits provided with respective whistle-forming means in which said substance is caused to vibrate at a frequency equal to or higher than sound frequency, whereby to apply to said substance a vibratory energy which causes its disper-
45 sion into highly divided particles, said circuits opening into a common reaction chamber in which the sound waves or ultrasonic waves generated by said substances are propagated, whereby said highly-divided particles are subjected in said chamber to the vibratory energy produced by the other circuits or at least by one portion of said
50 other circuits, thereby applying a strong stirring action to said particles and further dividing them.

65 It will be seen that the sound-wave or

ultrasonic-wave frequency vibration generated by these fluids themselves in the reaction chamber applies a strong stirring action not only to the particles formed in the circuits but also to the different substances or to the products of the reaction or transformation of said substances which are in said chamber. Due actually to the great number of circuits formed in a relatively restricted space, each circuit constituting a source of sound waves or ultrasonic waves, the particles of the thus treated substances as well as the substances themselves are subjected in the reaction chamber proper to a strong stirring action whereby these particles are divided again by being simultaneously broken and mixed, that is, under the best possible conditions for producing their chemical combination or any other desired transformation.

According to another feature of this invention, each particle issuing from a given circuit is caused to flow under the influence of gravity or of any other physical action through the sound-wave or ultrasonic-wave fields generated by the other circuits or at least one portion thereof.

The fact of gathering or concentrating in each reduced space a large quantity of ultrasonic-wave sources, and causing the particles issuing from one of these sources (and therefore already divided particles (to be compulsorily subjected to the action of the other sources, constitutes a kind of automatic multiplication of the effects produced by the sound waves and ultrasonic waves.

According to another feature of this invention, the circuits opening into said reaction chamber are so distributed that the sound waves and ultrasonic waves are concentrated in said chamber or at least in certain zones thereof, in order to increase locally the strength of the vibratory energy.

This energy increment permits on the other hand of increasing the stirring of the particles and their relative frictional contact, thereby promoting phenomena such as aggregation, dispersion, coalescence, ionization, cavitation, or phase transformation and in certain cases even breaking the molecules themselves, thus producing a cracking effect.

To adjust the physical transformation or the chemical reaction within the reaction chamber, a variable number of circuits opening into this chamber are cut off in order to regulate the fluid outputs by varying or not the fluid pressure.

The transformation or reaction may take place in a gaseous or liquid medium, or also in vacuo.

This invention is also concerned with a device for carrying out the method set forth hereinabove, this device being remarkable notably in that it comprises essentially a vessel affording a reaction chamber of which

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at least one wall consists of or is at least partially comprised of a member provided with a plurality of whistles as herein described, opening at spaced intervals on at least one face of said members, each whistle constituting or forming part of, a circuit through which a fluid is admitted for example under pressure, whereby said member constitutes both a fluid delivery device and a multiple generator of sound waves and ultrasonic waves.

According to a typical embodiment, said member consists of at least one substantially parallelepipedic plate having formed therein, for example by machining, a plurality of whistles preferably of the same type, having their outlets on at least one face of said plate.

It will be seen that with this specific construction of the member generating the sound or ultrasonic waves the whistles are concentrated locally, thus causing a multiplication of their effects.

According to another embodiment, said member consists of at least one body of revolution having formed therein, for example by machining, a plurality of whistles preferably of the same type having their outlets on at least one face of said member.

This invention is also concerned with the practical applications of the device broadly set forth hereinabove, notably to saponification, esterification and evaporation reactions, to the production of aerosols or hydrosols, to the control of the speed of transformation or chemistry, biology and physics.

Other features and advantages of this invention will appear as the following description proceeds with reference to the accompanying drawings, in which:

Figure 1 is a diagrammatic perspective view showing a first embodiment of the device according to the present invention;

Figure 2 is a generator consisting of two elements of parallelepipedic configuration which are disposed in parallel relationship;

Figure 3 is a generator of the type illustrated in Figure 2 but wherein the two elements are inclined to each other;

Figure 4 is a cylindrical generator associated with a reflector;

Figure 5 is a generator consisting of two elements of revolution;

Figure 6 is a diagrammatic section showing a cylindrical generator according to an alternative embodiment;

Figure 7 is a section taken upon the line VII—VII of figure 6;

Figure 8 is a diagrammatic view showing a regulating device for cutting off a number of whistles;

Figure 9a and 9b illustrate also diagrammatically a modified-embodiment of a regulating device;

Figure 10 illustrates in diagrammatic form

a saponification plant constructed according to the teachings of this invention, and

Figure 11 is a view similar to Figure 10 but showing an esterification plant.

Referring to Figure 1, there is shown in a purely diagrammatic form a device for carrying out the method of this invention, this device comprising a vessel, vat or like container 1 of which the bottom consists of a member 2 formed with a plurality of ducts provided with nozzles or cavities constituting as many elementary whistles 3 leading to the upper face of this member 2.

These whistles communicate for example with feed lines or ducts (not shown) through which one or more fluids may be fed for example under pressure, whereby these fluids will flow through the whistles 3 into the vessel 1.

These feed lines or ducts may be either formed within the member 2 or disposed externally thereof; their number is immaterial, each duct feeding a single whistle or a series of whistles. The whistles 3 may be of any suitable type, the term "whistle" denoting herein any member or device capable of producing sound waves and/or ultrasonic waves by the passage, whether direct or not, of fluid streams or jets therethrough. These whistles may be formed for example by either properly machining the material of member 2, or stacking laminated elements of any suitable thickness in which cavities are formed. These whistles may also be constructed separately and secured by welding or otherwise to constitute a compact assembly or unit. These whistles may furthermore consist of a material adapted to be moulded or extruded to constitute for example a sound pipe of cylindrical, toroidal or other configuration. This material may be sufficiently flexible to enable the variable pressure exerted by an auxiliary liquid on the whistles to modify the dimensions of these whistles and thus vary the output of the fluid or fluids flowing therethrough together with the characteristics of the sound and ultrasonic waves thus emitted.

It is known that the circulation of the fluid under pressure in whistles of this general type produces, by virtue of resonance phenomena, sound waves or ultrasonic waves the frequency of which is subordinate to the frequency of the pulses applied to the fluid streams or jets circulating through said nozzles or cavities, the pulse themselves being dependent on the geometrical dimensions of said nozzles or cavities, on the fluid pressure or fluid viscosity. Simultaneously the periodic breaking of the fluid jets entrained in the form of vortices through said resonant cavities causes the fluid to be divided into very fine particles. The particles thus flowing into the vessel 1 are subjected to the action of the sound or ultrasonic

waves produced by each one of said whistles and propagate throughout the interior of said vessel. Thus it will be seen that each particle issuing from a given whistle enters the operative zone of the other whistles so that it is subjected not only to the vibratory energy of the waves emitted by the whistle concerned but also to the vibratory energy of the waves emitted by the complete series of whistles. Under these conditions the particles are subjected to a strong mechanical stirring which mixes them thoroughly and causes a further division of these particles.

According to the type of treatment contemplated the elementary whistles may be fed either separately or by groups with different fluids, or alternatively all the whistles may be fed with a single and same fluid. The fluid or fluids is or are delivered preferably under pressure through the whistles with the assistance of volumetric or other pumps, alternative methods consisting in applying a suction to these whistles or causing the fluid or fluids to flow through the whistles by gravity, by pulse, etc. . . The choice of a preferred whistle type, of the whistle dimensions, of the feed pressure for the fluid or fluids, with a view to bringing about a given physical transformation or chemical combination, depends essentially on the properties of the fluid or fluids to be treated, on the final size of the particles to be produced, on the type of material, or on the kind of desired treatment.

As a substitute for the arrangement illustrated in Figure 1, two elements 2a, 2b in the form of parallelepipedic plates may be used of which the operative faces, that is, those carrying the whistles such as 3a, register with each other as illustrated in Figures 2 and 3. These parallelepipedic elements may either be disposed in parallel relationship (Figure 2) or form an angle to each other (Figure 3). If these elements are disposed at an angle to each other the reaction chamber consists of the space available between the operative faces. The elements 2a and 2b may be provided with adjustment means (not shown) of any suitable and known type for varying at will their relative spacing and/or their relative inclination. Thus, these adjustment means may be purely mechanical, such as rack-and-pinion or worm-and-wheel devices, or electrical, magnetic, pneumatic or other. These means may be controlled either manually or automatically.

If desired, a plurality of pairs of elements of this type may be disposed in any suitable manner; thus, each wall of a vessel such as 1 may be provided with or made of an element 2. Of course, the plates 2 may have any desired and suitable shape, for example triangular, polygonal or with any suitable curvilinear contour.

The sound-wave or ultrasonic-wave gener-

ator may also have a form of revolution, for example the form of a cylindrical core 4 having a central cavity 5 and provided with the whistle outlets on its outer periphery, as illustrated in Figure 4. These whistles may either communicate with one or a plurality of ducts connected to the central cavity of said cylinder, or lead directly into said cavity. Advantageously, the generator of sound waves or ultrasonic waves may be associated with reflectors disposed in front of the operative surface and adapted to either reflect the sound and ultrasonic waves in a selected or privileged direction, or concentrate these waves in a predetermined zone of the reaction chamber. These reflectors may also be adapted to produce interference phenomena between the waves issuing directly from the whistles and those reflected by the reflectors. Reflectors of this type may have any desired shape, for example flat, cylindrical, spherical or parabolic. Figure 4 illustrates a reflector 6 of part-cylindrical shape associated with a cylindrical core 4 and disposed within a reaction chamber so as to focus the waves emitted by the whistles 3 and create locally a high energy concentration. This reflector is preferably adjustable and may be operated by means similar to those contemplated for adjusting the position of the generators themselves.

The sound-wave or ultrasonic-wave generator may also consist of a frustoconical, spherical, part-spherical, ellipsoidal or otherwise shaped member. Two or more members of this character may be used and disposed for instance co-axially with a view to forming therebetween an annular space constituting the reaction chamber. Figure 5 illustrates a device of this type which comprises a cylindrical core disposed inside a frustoconical member 7, the space left between these two members constituting the reaction chamber.

The direction in which the whistles are set relative to the outer wall of the sound-wave or ultrasonic-wave generator is immaterial, this orientation determining of course the direction of the jet of fluid particles issuing from each whistle. However, it may be advantageous to set adjacent whistles in different directions in order to increase the mixing action applied to the particles by creating systematically flow discontinuities therein. Thus, in the case of the cylindrical generator, for example (see Figures 6 and 7), the whistles delivering the particles at a certain level are set in the direction opposite to that of the whistles delivering particles at an adjacent level in order to provide throughout the height of the cylinder two or more series of whistles having opposite directions and forming alternative layers. It will be readily understood that with this specific arrangement the fluid de-

livered through the ducts 9 and the peripheral manifold 10 penetrates into the reaction chamber 11 in the form of oppositely directed streams or jets of particles which, when they meet each other, produce vortex effects increasing the mixing and stirring action while improving the homogeneity of the mix.

To adjust the fluid output delivered by the sound-wave or ultrasonic-wave generating member, a predetermined number of whistles may be cut off for instance by means of a shutter member adjustable in different settings.

Figure 8 illustrates a specific example of an adjustment member of this type which consists of a piston or slide valve 12 or like element slidably mounted in a cylinder 4 carrying whistles disposed at spaced intervals. It will be seen that the piston 12 will cut off a variable number of whistles according to its axial position in the cylinder.

Figure 9a illustrates an adjustment member consisting of a rotary sleeve 13 formed with slots 14 of different lengths and housed within a hollow cylindrical generator 4 carrying whistles disposed along a helical path on the inner wall of said cylinder. To simplify the drawing in Figure 9b it is assumed that the cylindrical sleeve is developed into a plane.

The output of the fluid or fluids may also be adjusted by modifying the fluid pressure, for example by means of a spring-loaded valve mounted in a by-pass line or through any other known and suitable means.

The members for adjusting the fluid output may be actuated manually or automatically. Thus, these adjustment members may be controlled by a self-regulating device responsive to a physical factor inherent to the treated medium, such as its pH value, density or temperature.

The treatment in the reaction chamber may be effected either in a gaseous medium, or in a liquid medium, or in vacuo, according to the type of material or materials to be treated or the fluids involved.

If it is desired to produce a chemical reaction between two or more substances, or to divide a solid with a view to preparing an aerosol or a hydrosol each substance is introduced separately into a set of circuits inherent to each specific substance whereby the substances are caused to contact each other and therefore to combine or mix together within the reaction chamber.

A chemical reaction between two or more substances, or an aerosol or hydrosol consisting of these substances, may also be obtained by introducing a mixture of these substances into the circuits, the mixing and chemical combination of the particles occurring exclusively, or at least being completed, in the reaction chamber.

In order to accelerate the physical transformation or the chemical reaction, the substances are processed by using different types of energy as may be derived from the application of heat, pressure, electrical phenomena, magnetic forces, electromagnetic pulses or nucleonic forces, or still from sound waves or ultrasonic forces, through the medium of an auxiliary source.

This additional energy may be supplied and applied in any suitable and known manner, for instance by incorporating in the device described and illustrated herein a heating system, for example an electrical heating system operating by Joule effect or by induction, the generator being placed in the static field of a condenser, or in the field of an electromagnet. The auxiliary sound or ultrasonic fields may be produced by any conventional generator of the magnetostriction, piezo-electrical or other type. Chemical reactions notably may be effected in the presence of a suitable catalyst.

The applications of the method and devices according to this invention are particularly numerous in the fields of physics, chemistry, and biology, as already explained hereinabove; its efficiency is due more particularly to a strong division of the treated substances, since mixes and emulsions having a particle size of less than $.10\mu$ have been obtained. It may be noted in this respect that one gram of water divided in particles of $.10\mu$ represents a surface greater than 650 square feet.

Figure 10 illustrates diagrammatically, by way of example, a saponification plant utilizing the method of this invention.

The tanks 21, 22 and 23 equipped with agitators 25 are filled respectively with tallow, coprah oil and soda. These products are heated by means of coils 24 to keep their temperature between 122° and 194° F.

A common motor 29 drives motoring pumps 28 delivering the products through filters 27 and heat-insulated lines 26, pressure-regulating devices 30 being provided for maintaining the pressures in the range of 28 to 70 p.s.i., the throughputs being indicated by suitable instruments 31.

The products are thus delivered to the device 32 heated to a temperature ranging from 122° to 212° F and wherein the saponification proper takes place. The saponified product is recovered through a drain pipe 33.

The device 32 may be of any one of the types described hereinabove and illustrated in the preceding Figures; thus, it may consist notably of a cylindrical generator of the type illustrated in Figures 6 and 7 but comprising three inlet pipes instead of two.

In a typical run, tallow, coprah oil and soda at 27° Bé in the volumetric ratios of 1, 3, 3 and at a temperature ranging from

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131° to 185° F have been mixed in a device having a height of 12" and an outer diameter of 8", equipped with whistles having a cross-sectional passage area of .00093 square inch and a density of 160 whistles per square inch, the resulting emulsion comprising a plurality of particles of a size equal to or smaller than 10 μ . At the outlet 33 of the apparatus the following saponification percentages were observed after the times (in seconds) indicated:

15"=65%
30"=80%
60"=97%
120"=99.5%

It should be noted that the hitherto known saponification apparatus give this percentage after a minimum time of 10 minutes.

Subsequent to this saponification step the product is directed through a spout or any other suitable means, during the time necessary for properly completing the reaction, to another device (not shown) in which the necessary quantity of acid, for example stearic acid, is incorporated in the product for effecting a satisfactory neutralization. In the example illustrated the quantity of stearic acid corresponding to the component ratios 1, 3, 3, was .02. Thus a soap without washing and without negro is obtained.

Figure 11 illustrates diagrammatically an esterification plant comprising as in the preceding case a series of tanks (two in this example), 21, 22 containing the materials necessary for carrying out the reaction, for example phthalic anhydride and glycol propylene.

The ultrasonic wave-generator 34 comprises two co-axial elements of frustoconical configuration.

The reaction products, that is, phthalic anhydride and glycol propylene, are fed through lines 35 and 36 and then through the whistles 37, 38 to the reaction chamber 39 disposed between the two frustoconical elements.

Nitrogen is fed through lines 40 to the lower portion of the device in which it penetrates through ducts 41 communicating with the whistles 42 having different angular settings in order to create a strong turbulence. The assembly is heated for example by an eddy-current device (not shown).

The nitrogen gas loaded with water steam is discharged through a line 43 for example into a condenser while the ester is drained through another duct 44.

A reactor having a height of 40" and a reaction chamber with an outer diameter ranging from 26" to 20" and a width of about 13" or 14" is used. The cross-sectional passage area of the whistles varies from .0000155 square inch (in the case of nitrogen) to .00155 square inch, with a density of 650 to 75 whistles per square inch. The inlet pressures ranged from 14 to 70

p.s.i., the temperature being maintained between 167° to 248° F. The acid-glycol proportion by weight was 3:2, the nitrogen output was .070 cu. ft. per minute, giving an ester output of about 1,100 pounds per hour.

Of course, the invention should not be construed as being limited by the embodiments described and illustrated herein, as they merely constitute typical examples thereof to which many modifications may be brought without departing from the scope of the invention as set forth in the appended claims.

WHAT WE CLAIM IS:—

1—Method of treating any substances, bodies, elements, chemical compounds or microorganisms, in the form of a fluid or a powdered solid or of highly comminuted solid particles in suspension in a carrier fluid, with a view to promoting and/or facilitating a physical transformation and/or chemical reaction involving said substances, which consists in causing at least one of said substances, for example with the assistance of pressure means, to circulate through a plurality of circuits provided with respective whistle-forming means in which said substance is caused to vibrate at a frequency equal to or higher than sound frequency, whereby to apply to said substance a vibratory energy which causes its dispersion into highly-divided particles, said circuits opening into a common reaction chamber in which the sound waves or ultrasonic waves generated by said substance are propagated whereby said highly-divided particles are subjected in said chamber to the vibratory energy produced by the other circuits or at least by one portion of said other circuits, thereby applying a strong stirring action to said particles and further dividing them.

2—Method according to claim 1, characterized in that each particle issuing from a given circuit is caused to flow under the influence of gravity or of any other physical action through the sound-wave or ultrasonic-wave fields generated by the other circuits or at least one portion thereof.

3—Method according to claim 2, characterized in that the circuits opening into said reaction chamber are set to produce vortex effects therein to increase the aforesaid stirring action.

4—Method according to claim 3, characterized in that the circuits opening into said reaction chamber at a certain level are set in a direction opposite to that of the circuits located at an adjacent level, thereby creating two series of alternating circuits emitting particles in opposite directions.

5—Method according to any of the preceding claims, characterized in that the circuits opening into said reaction chamber are so distributed that the sound waves and

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ultrasonic waves are concentrated in said chamber or at least in certain zones thereof, in order to increase locally the strength of the vibratory energy.

5 6—Method according to any of the preceding claims, characterized in that the sound waves and ultrasonic waves are caused to be reflected within said reaction chamber in order to promote the energy concentration.

10 7—Method according to any of the preceding claims, characterized in that the physical transformation and/or the chemical reaction can be adjusted at will in said reaction chamber by varying the number of said circuits and/or by modifying the pressure of said fluid or fluids.

15 8—Method according to any of the preceding claims, characterized in that said physical transformation and/or chemical reaction within said reaction chamber are carried out either in a gaseous medium, or in a liquid medium, or in vacuo.

20 9—Method according to any of the preceding claims, characterized in that when it is desired to produce a chemical reaction between two or more substances, or to divide a solid with a view to producing an aerosol or a hydrosol, each one of these substances is introduced separately into a series of circuits consistent with each specific substance whereby all the substances are caused to contact with each other and therefore to combine or mix together in said reaction chamber.

25 10—Method according to any of the preceding claims, characterized in that the chemical reaction between two or more substances or the formation of an aerosol or a hydrosol is obtained by introducing a mixture of said substances in said circuits, the mixing and the chemical combination of the particles occurring exclusively or being at least completed in said reaction chamber.

30 11—Method according to any of the preceding claims, characterized in that the physical transformation or the chemical reaction may be accelerated by subjecting the substances involved to different forms of energy as may be derived from the action of heat, pressure, electrical phenomena, magnetic, electromagnetic or nucleonic actions, or sound or ultrasonic effects, with the assistance of a suitable auxiliary source.

35 12—Method according to any of the preceding claims, characterized in that the chemical reaction, within said reaction chamber takes place in the presence of a catalyst.

40 13. A device for treating any substances bodies, elements, chemical compounds or microorganisms, in the form of a fluid or of a powdered solid or of highly comminuted solid particles in suspension in a carrier fluid, with a view to facilitating their physical transformation and/or to increasing their

chemical reactivity, said device comprising essentially a vessel affording a reaction chamber of which at least one wall consists of or is at least partially comprised of a member provided with a plurality of whistles as herein described, opening at spaced intervals on at least one face of said member, each whistle constituting, or forming part of, a circuit through which a fluid is admitted for example under pressure, whereby said member constitutes both a fluid delivery device and a multiple generator of sound waves and ultrasonic waves.

70 14—Device according to claim 13, wherein said member consists of at least one substantially parallelepiped plate having formed therein, for example by machining, a plurality of whistles preferably of the same type, having their outlets on at least one face of said plate.

75 15—Device according to claim 14, wherein said member comprises at least one pair of plates of the type aforesaid, having their operative faces, that is, the faces with the whistle outlets, registering with each other.

80 16—Device according to claim 15, wherein the plates constituting each pair aforesaid are parallel to each other.

85 17—Device according to claim 15, wherein the plates constituting each pair aforesaid are set at an angle to each other.

90 18—Device according to any of claims 15, 16 and 17, wherein manual or automatic control means are provided for modifying at will the relative spacing, the relative inclination or the angular setting of of the plates constituting each pair aforesaid.

95 19—Device according to claim 13, wherein said member consists of at least one body of revolution having formed therein, for example by machining, a plurality of whistles preferably of the same type having their outlets on at least one face of said member.

100 20—Device according to claim 19, wherein said body of revolution consists of a cylindrical core preferably of circular cross-sectional shape, the outlets of said whistles being disposed preferably on the outer surface of said cylindrical core.

105 21—Device according to claim 19, wherein said body of revolution consists of a hollow cylinder preferably of circular cross-sectional shape, the outlets of said whistles being disposed on the inner and/or outer surfaces of said cylinder.

110 22—Device according to claim 19, wherein said body of revolution consists of a hollow frusto-conical member, the outlets of said whistles opening on the inner and/or outer surface of said member.

115 23—Device according to claim 13, wherein said member consists of two or more bodies of revolution disposed co-axially in relation to each other.

120 24—Device according to claim 23, where- 130

in said reaction chamber consists of the space available between said elements.

- 25—Device according to any of claims 13 to 24, wherein at least one of the elements constituting the sound-wave or ultrasonic-wave generator constitutes one of the walls of said reaction chamber.

- 26—Device according to any of claims 13 to 25, wherein reflector means are disposed in front of and/or between said elements for focusing the sound waves or ultrasonic waves in a privileged region of said reaction chamber and/or causing interference phenomena between incident and reflected waves to take place.

- 27—Device according to any of claims 13 to 26, wherein said member is provided with adjustment means operative for preventing fluid flow through a predetermined number of whistles and thus vary at will the quantity of fluid admitted into said chamber.

- 28—Device according to claim 27, wherein said adjustment means consists of a piston, slide valve or like element slidably mounted in said member and operative to obturate or cut off a variable number of whistles at will.

- 29—Device according to claim 27, wherein said adjustment means consists of a rotary sleeve of cylindrical configuration having formed on its peripheral surface a series of slots of different lengths which ex-

tend at right angles to the sleeve axis and are adapted to close said whistles more or less according to the angular position of said sleeve.

- 30—Device according to any of claims 27, 28 and 29, wherein said adjustment means is actuated by a mechanism controlled manually or automatically.

- 31—Device according to claim 30, wherein said adjustment means is actuated by a self-regulating device responsive to a physical factor inherent to the treated medium, such as the pH value, the density or the temperature.

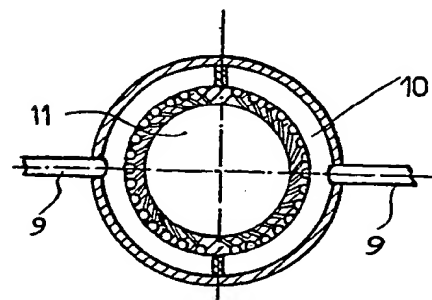
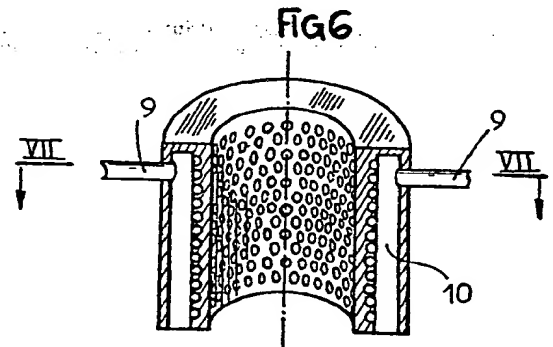
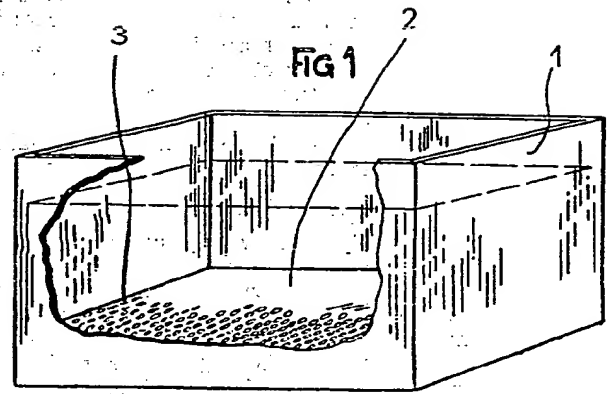
- 32—Device according to any of claims 13 to 31, wherein said whistles are made from a flexible material whereby the pressure exerted by an auxiliary fluid may cause their dimensions to vary and thus alter at will the fluid output as well as the characteristics of the emitted sound waves or ultrasonic waves.

- 33—A method substantially as described hereinabove with reference to the accompanying drawings.

- 34—A device substantially as described hereinabove with reference to the accompanying drawings.

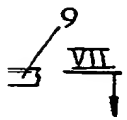
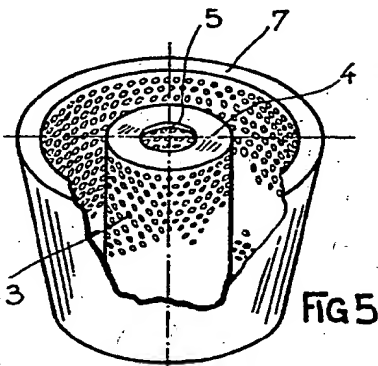
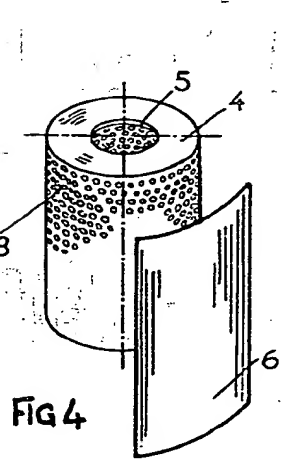
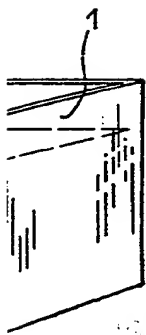
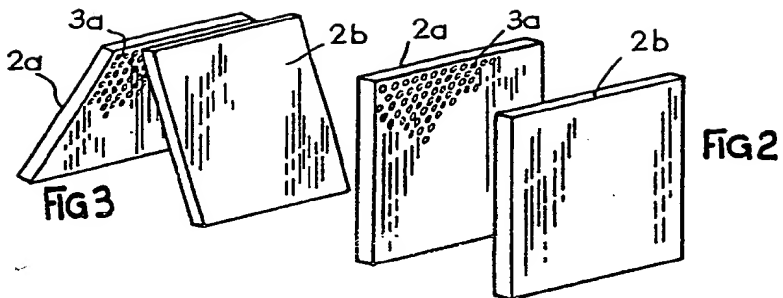
GEE & CO.,

Chartered Patent Agents,
51—52, Chancery Lane, London, W.C.2, and
22, Whitefriargate, Hull.
Agents for the Applicants.



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Sheet 1



10

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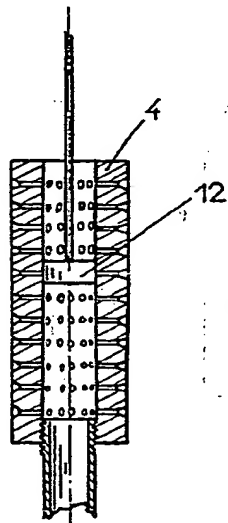


FIG 8

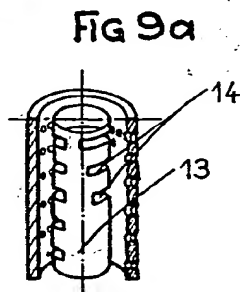


FIG 9a

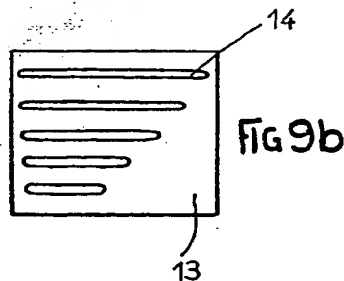
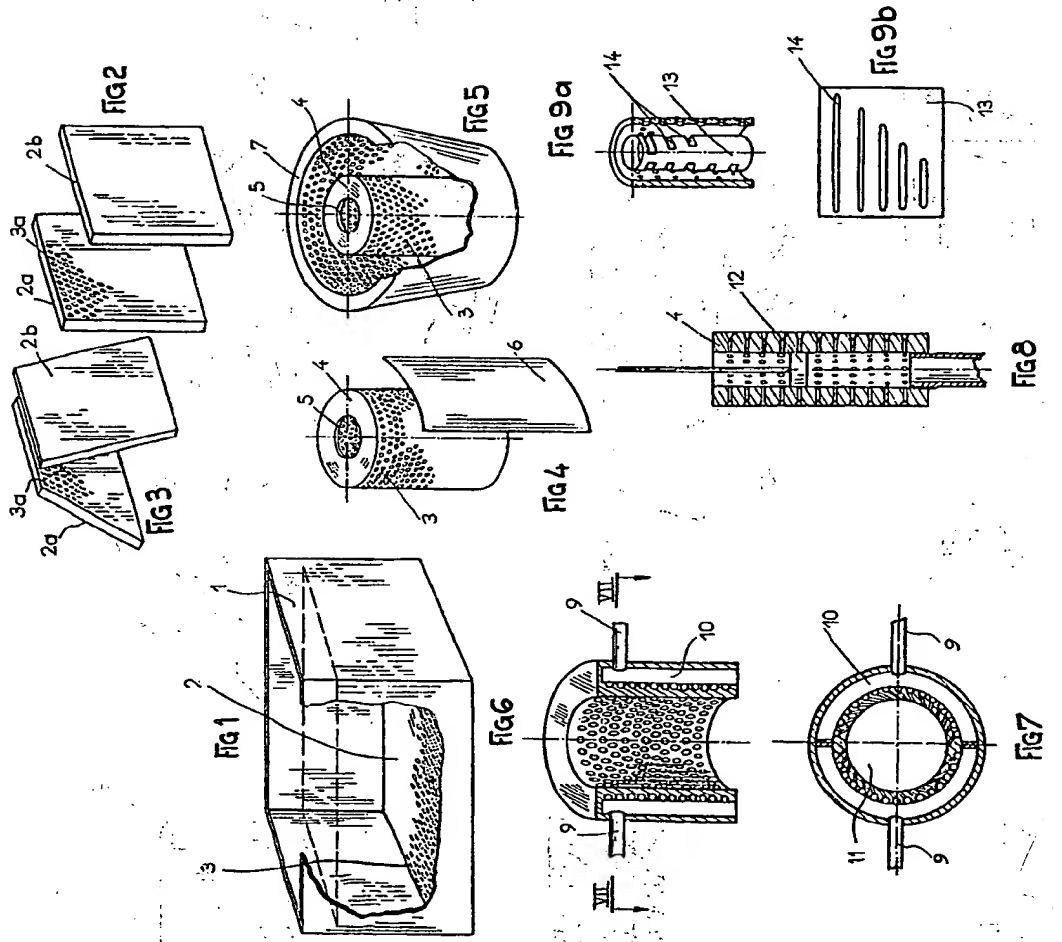


FIG 9b



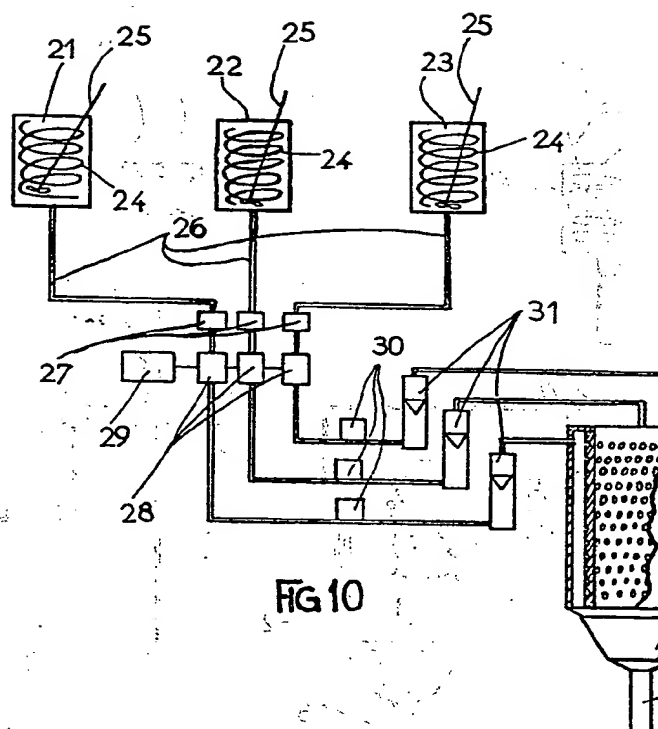


FIG 10

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Sheet 2

FIG 11

